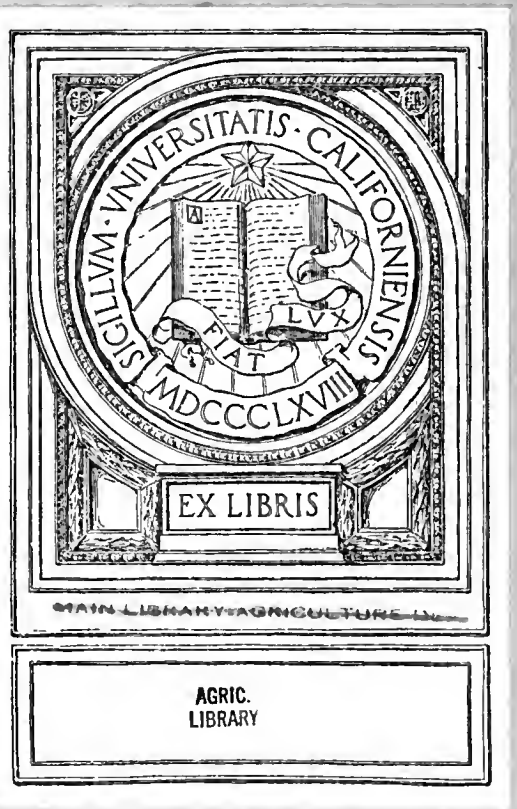

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THE SMUTS OF MILLET,

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Bulletin No. 18.

(BOTANICAL SECTION.)

THE SMUTS OF MILLET (*Andropogon Sorghum Brot.*),

The Long Smut (*Tolyposporium filiferum Busse*).

The Long Smut is the most common smut of millet in Egypt and its occurrence can be compared with that of loose smut of wheat. It occurs in almost every crop of millet throughout the country, but not in sufficient quantity to cause an appreciable decrease in the yield. This is partly due to the fact that the number of heads attacked hardly ever reaches as much as two per cent, and partly because only the individual grains are attacked by the fungus. The number of grains attacked in a single head may be anything from five to sixty, but on an average about fifteen.

When a grain is attacked it is replaced by a spore-sac which measures 15 to 31 millimetres long by 4 to 5 millimetres broad. The disease is conspicuous and easily recognizable (Plate 1, Fig. 1). The spore-sac splits longitudinally, starting at the tip usually, exposing eight to ten dark brown filaments surrounded by a powder of the same colour. The filaments are the isolated fibro-vascular bundles of the enlarged ovary (Plate I, Fig. 2). If a little of the powder is placed in water on a slide and examined microscopically it will be found to consist of several spore balls which are composed of a number of closely adhering spores (Plate I, Fig. 3). The individual spores are coverd with warts on the free surfaces and smooth on the sides by which they were attached to the other spores of the spore balls (Plate I, Fig. 4). The spores are brown, round, but somewhat flattened on the smooth sides and measure 10 to 15 μ in diameter. They germinate readily in a one per cent solution of cane sugar and normally produce a three-celled thread (promycelium). Each of the cells of the promycelium then gives rise at its tip, or laterally near the septa, to small unicellular structures called sporidia (Plate I, Fig. 5). The spores on germination also produce septate germ tubes which then give rise to sporidia. Sporidia which have become detached from the cells of the promycelium give rise to secondary sporidia.

The life history of the fungus is not yet known. It has been observed that in the case of a single plant bearing three heads, only seven grains in the youngest head were affected, whilst all the grains in the other two heads were healthy. This supports a statement made by Butler to the effect that possibly it may be due to a localized infection of a single flower.

It is a custom of the felaheen of the provinces of Minya and Asyût to eat the fungus when young, and it is said to have a peculiar sweet taste. The eating of the fungus, although a perfectly sound method of controlling the disease, cannot be recommended or condemned here because the effect of large quantities of this fungus on the health of the consumer is not known. The only recommendations that can be given for treatment of the disease are :—

(1) Obtain seed from a healthy crop.

(2) Remove and burn the spore-sacs when young.

(3) Where possible, do not grow millet for a few years on soil where the disease has occurred.

The Head Smut (*Ustilago reiliana Kuehn.*).

The disease caused by the Head Smut is of rare occurrence in Egypt and the loss caused by it is negligible It is also known in India, Southern Europe, U.S.A., and Asia.

Usually the millet ear is converted into a large spore-sac (sorus) which measures 7·5 to 10 centimetres long by 3·75 to 5·5 centimetres broad (Plate II, Fig. 1). The grey membrane of the sorus usually ruptures before emerging from the sheathing leaves, exposing a network of dark brown almost black fibrous filaments, surrounded and intermingled by a powder of the same colour. The fibrous filaments are the fibro-vascular bundles of the millet and the powder is composed of the spores of the fungus (Plate II, Fig. 2). Intermingled with groups of sterile, hyaline cells. The hyaline cells measure 7 to 15 μ in diameter. The spores are dark brown, round, covered with small spines and measure usually 13 μ in diameter. The size of the spores is very uniform. They germinate readily in a one per cent solution of cane sugar and produce a short, thick, four-celled promycelium, bearing sporidia at the apex and near the septa (Plate II, Fig. 3). The sporidia bud off other sporidia readily and remain joined end to end to form chains. The spores retain their power of germination for as long a period as eight years.

Infection of the flowers does not take place in the case of this disease. The method of infection is usually from spores which are present in the soil. These attack the young millet seedling so that the whole plant becomes infected, resulting in the production of a

smutted ear. Sometimes only the lower portion of the ear becomes infected and the upper portion may grow out to form leafy shoots. This fungus also causes the Head Smut of maize.

Special treatment is unnecessary against this disease at present, but it is advisable to cut and burn diseased ears, at the same time preventing the spores being shed on the ground. In the event of a severe local attack taking place millet should not be grown on that soil for five years. By that time probably most of the spores will have germinated and perished.

The Grain Smut (*Sphaceolotheca sorghi, Lk., Clinton*).

The Grain Smut occurs more often than the Head Smut and less often than the Long Smut. The loss caused by the disease is negligible at present. It is known in most parts of the world where millet is grown, and is said to cause great losses sometimes in different parts of India.

As in Long Smut the individual grains are attacked. The number of diseased grains exceeds that in Long Smut, and cases where every grain in a head is infected are not infrequent. It has also been observed that some grains may be attacked by Long or Head Smut and some with Grain Smut. The attacked grain is replaced by a grey, oval, spore-sac (sorus), measuring 4 to 12 millimetres long by 2 to 3 millimetres broad. The glumes remain unaltered and can be seen surrounding the bases of the sori (Plate III, Figs. 1 and 2). The wall of the sorus becomes ruptured fairly easily. The sac is filled with a dark brown mass of spores and a central, rigid, slender, column of tissue (Plate III, Fig. 3). The latter is composed of the tissue of the millet and is traversed by fibro-vascular bundles. The spores when seen in mass are dark brown, but when placed in water they soon separate into individual spores, and on examining under a microscope they will be seen to be light brown in colour, slightly oval or round, smooth, and measure 5 to 7 μ in diameter (Plate III, Fig. 4).

Spores from specimens of the disease collected this year germinated readily in water. They can, however, retain their germinating powers for as long a period as six years or more. Spores placed in water vary considerably in their method of germination. Some produce a four-celled promycelium the cells of which give rise to spindle-shaped sporidia (Plate III, Fig. 5). The latter rarely bud off secondary sporidia. Other spores, instead of forming sporidia, give rise to germ tubes laterally and apically from the cells of the promycelium. Again some spores do not produce a definite promycelium, but instead septate branching germ tubes are formed.

Infection takes place in the same manner as in the closed Smut of barley. Spores adhere to the seed coats, and when sown together

germination of the seed and spores takes place. The young seedling then becomes infected between the time of germination of the seed and appearance of the seedling above the ground. As with barley there is no method by which a diseased plant can be distinguished from a healthy one in the field, until the ears are formed when the diseased produce smutted grains. It is not likely that infection takes place from spores in the soil, particularly in Egypt, where the soil is irrigated. This method of watering at intervals, coupled with a variation in the temperature of the soil between one season and another, probably ensures the germination of most of the spores in the soil and their death in the absence of millet seedlings.

Treatment.

The treatment of this disease must aim at killing the spores adhering to the seed coats by some means which will not appreciably interfere with the germination of the seed. There are several methods of disinfecting the seed, but only two will be considered here because they are as effective as the others and at the same time simpler. They also serve a double purpose as stated below.

(1) *Copper Sulphate.*—The seed is immersed in a two per cent solution of copper sulphate for ten minutes, spread out on sacking or a clean floor and allowed to dry. The seed is then ready for sowing. In some countries the seed is sprinkled with the solution instead of immersing, but the latter is recommended here because: (1) any spore-sacs which may be amongst the healthy seed will float on the surface of the liquid and can easily be skimmed off; (2) many of the seeds are attacked by weevil and these also float on the surface of the liquid and can be removed; (3) the bad seed float on the surface. To do this thoroughly the seed should be stirred for two or three minutes. Even in the absence of Smut it is advisable for the above reasons to immerse the seed in water and after stirring to remove those remaining on the surface. This will save much time, labour, and the cost of resowing. A wooden and not a metal vessel must be used when making the solution. The solution can be used over and over again as long as it is not allowed to evaporate. If the seed is to be put back in the same basket (*maqtaf* or *ghalaq*) or sack after treatment, it should be first immersed in the solution so as to prevent the seed becoming contaminated with the spores of the fungus which may be left in the basket or sack. There is no objection to immersing the basket containing the seed in the solution provided the seed is stirred and those that float are removed.

(2) *Formalin.*—The seed is immersed in a half per cent solution of commercial formalin (*i.e.* containing 37 to 40 per cent formaldehyde) for two hours, then spread out on the ground and allowed to dry rapidly in the sun. The remarks made above with reference to the removal of floating seed and spore-sacs apply in this case also. The seed should then be sown as soon as possible.

Cost of Treatment.

Formalin.—Four or five *qadahs* of millet seed are usually sown per *feddân* in Egypt. Four *qadahs* are equal to eight litres, so that ten litres of the solution will be ample for treating sufficient seed for one *feddân*. A half per cent of ten litres is 50 c.c. and this is the amount of formalin required. Commercial formalin (*i.e.* containing 37 to 40 per cent formaldehyde) when bought wholesale costs P.T. 55 per litre. Thus the cost of treating the seed with formalin is P.T. 2·75 per *feddân*. If the solution is used for a second lot of seed this will of course reduce the cost of treatment to Mms. 14 per *feddân*, and so on.

Copper Sulphate.—Copper sulphate can be bought at P.T. 15 per kilogramme, so that 200 grammes (*i.e.* the amount necessary for making ten litres of 2 per cent solution) costs P.T. 3. Three cultivators using the same solution for treating sufficient seed for one *feddân* each can, by sharing the cost, do so at P.T. 1 each.

The methods of seed disinfection described above were demonstrated this year in twelve different parts of Egypt. Each lot of seed was divided into three portions. One portion was sown untreated, another after treating with two per cent copper sulphate, and the third sown after treating with half per cent formalin. The result showed that the chemical had no ill effect on the germination of the seed. In all the treated and untreated plots Long Smut was present showing that disinfection of seed is ineffective against Long Smut. Head Smut did not occur in any of the treated or untreated plots. In eleven out of twelve experiments Grain Smut was also absent, but in the twelfth it appeared in the untreated only. There was no Grain Smut in the treated plots of this experiment. This shows that treatment of seed with copper sulphate or formalin is effective against Grain Smuts.

Bibliography.—"Fungi and Disease in Plants," Butler.

Explanation of the Plates.

Plate I.—Long Smut (*Tolyposporium filiferum Busse*) :—

Fig. 1.—Portion of Millet Head showing long spore-sacs (natural size).

Fig. 2.—Spore-sac opened to show filaments (natural size).

Fig. 3.—Spore ball.

Fig. 4.—Spores.

Fig. 5.—Spores germinating.

Plate II.—Head Smut (*Ustilago reiliana Kuehn*) :—

Fig. 1.—Smutted ear (natural size).

Fig. 2.—Spores (× 650).

Fig. 3.—Spores germinating (× 650).

Plate III.—Grain Smut (*Sphaceolotheca sorghi*, Lk., Clinton) :—

Fig. 1.—Smutted ear (natural size).

Fig. 2.—Smutted grain.

Fig. 3.—Central portion remaining after shedding of spores.

Fig. 4.—Spores (× 650).

Fig. 5.—Spores germinating (× 650).

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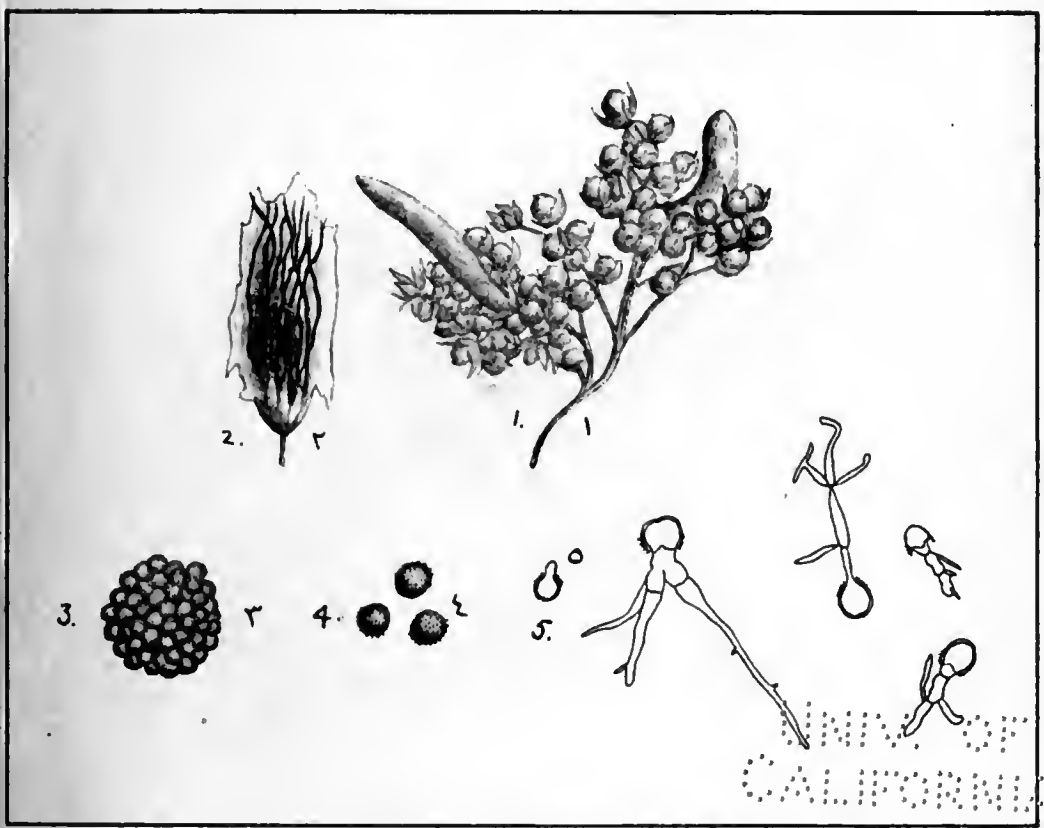

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FIGS. 1-4: Del. M. Mamoun; FIG. 5: Del. H.B.-J.

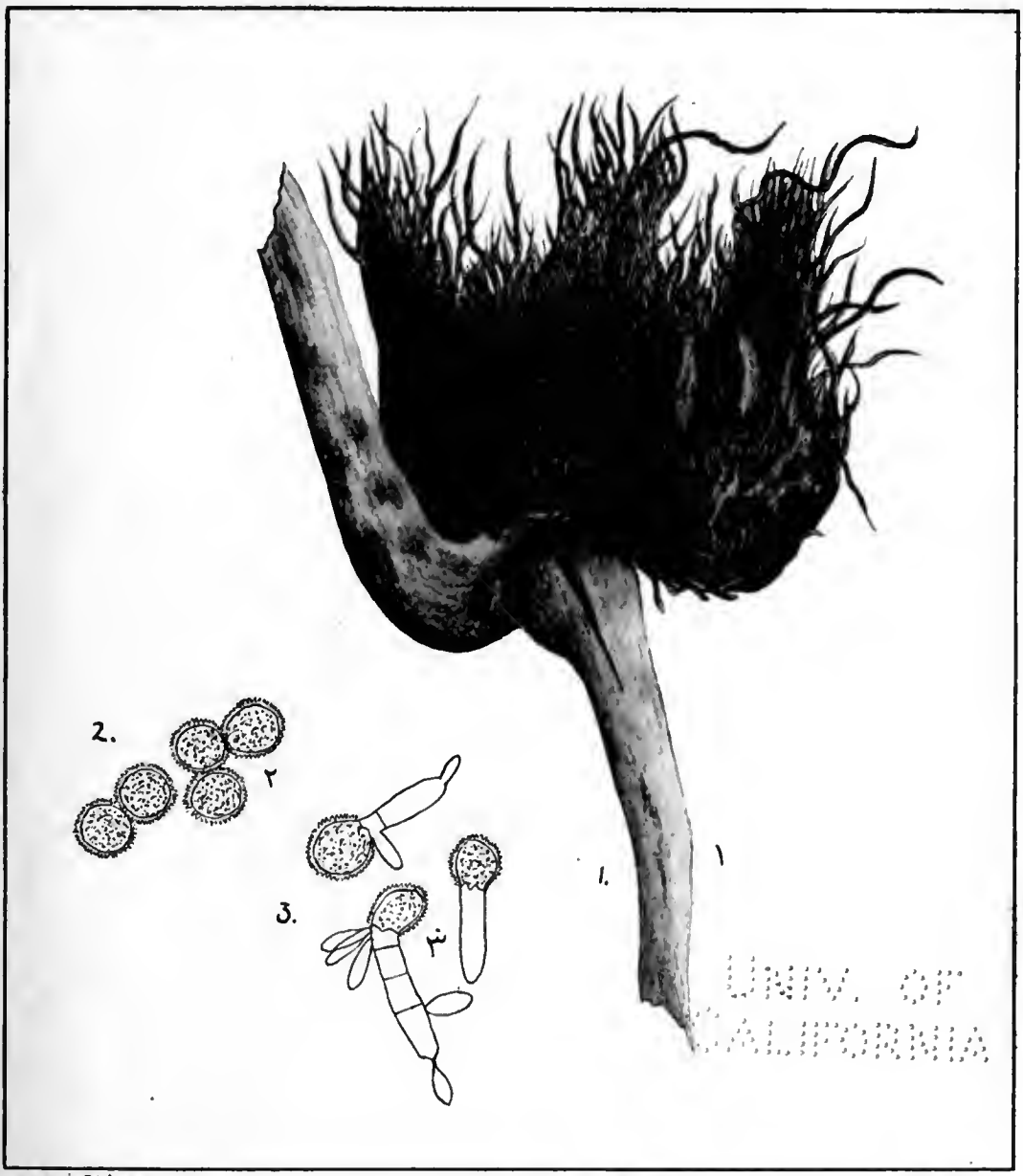

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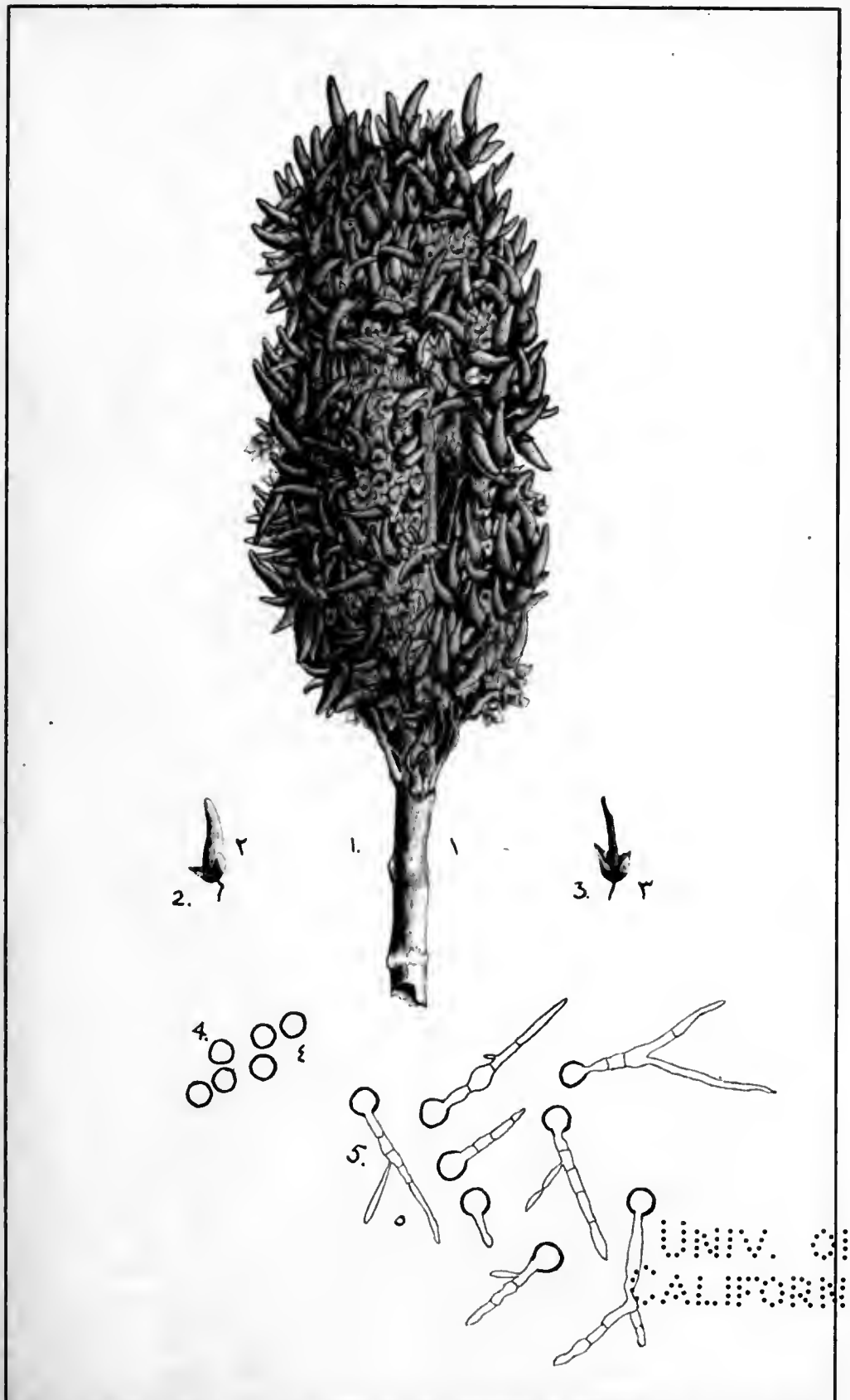
FIG. 1 : Del. M. Mamoun; FIGS. 2 AND 3 : Del. H.B.-J.



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FIGS. 1, 2, AND 3: Del. M. Mamoun; FIGS. 4 AND 5: Del H.B.-J.